4 Payload Interface Requirements

Compliance to the requirements in this section ensure a payload can be successfully integrated and operated within the [illegible] Black Box. This section is divided by the following disciplines: Structural, Electrical, Environmental, Safety and Human Factors

4.1 Safety Requirements

All payloads must complete the NASA Safety Review Process conducted by the ISS Safety Review Panel (ISRP). The Voyager Exploration safety group interfaces directly with the ISRP to complete this process for each payload. The following sections contain requirements that must be met for Voyager Exploration to get your payload approved to fly by NASA Safety.

4.1.1 Safety Criticality Definitions

The ISRP makes the following determinations on safety criticality for payload structures and circuitry. These levels of safety criticality may trigger additional requirements and verification efforts.

1. **Safety Critical Structures:** Levied on payloads containing hazardous or shatterable materials and requires additional evaluation and verification to ensure that structural failure resulting in a hazardous condition does not occur.
2. **Vibration Sensitive Safety Critical Structures:** Levied on payloads without adequate levels of containment for hazardous materials, or where the launch vibration environment could otherwise result in a structural failure and hazard to the crew. The vibration sensitive determination may trigger the need to conduct additional vibration testing.
3. **Safety Critical Circuits:** Levied on payloads containing circuitry that controls a hazard and requires additional evaluation and verification to ensure that circuit failure resulting in a hazardous condition does not occur.

*note that for payloads determined to fall into one of these categories any additional required testing or analysis triggered will be the responsibility of the Payload provider unless otherwise coordinated and agreed in the ICA.

4.1.2 Debris and Shatterable Materials

Payloads **shall not** generate debris during launch or normal mission operations.

4.1.2.1 Shatterable Materials

If the hardware contains shatterable materials, the hardware **shall** provide containment to ensure that no particles 50-micron or larger are liberated.

Any shatterable materials used in the payload design must be defined in the payload ICA and any hardware containing shatterable materials must be packed in a clear sealed bag for transport to ISS. This will allow the crew to conduct a visual inspection for fracture/debris before the payload is deployed for operations. This is the minimum constraint for which the Payload Provider must accept risk to prevent a debris/frangible hazard.

If the Payload Provider wants to reduce risk of hardware damage during transport to the ISS due to the load environments shown in Section 4.1.1, the Payload Provider should specify additional packing constraints in the ICA. Packing options may consist of bubble wrap, custom cut foam padding, or even custom fabricated hard enclosures.

4.1.2.2 Rotating Equipment

Hardware containing rotating equipment shall provide containment such that no rotating parts can be liberated from the payload AND any rotating components shall be less than 200 mm in diameter and rotate at less than 8000 RPM max. All rotating components within the payload must be identified and documented in the payload specific ICA.

4.1.3 Pressure Systems

Nanolabs do not typically employ pressurized gas systems as this introduces further Safety and Interface Verification and risk. However, if required by the experiment, any such system requires additional evaluation and coordination for approval, and if approved will likely extend the integration schedule. Use of pressure systems must be agreed in advance and defined in the contract and ICA.

Payloads with pressurized gas systems which have a total expanded gas volume exceeding 400 liters at Standard Conditions **shall** limit the gas flow after a single failure to less than 240 SLPM after 400 liters at Standard Conditions has been released to the cabin air. This applies to payloads for both on-orbit and transport time periods.

4.1.4 Hazardous Materials

4.1.4.1 Toxicology and Microbiology

Payloads **shall** pass a JSC Toxicology and Microbiology Review. The assessment by the two groups is established as the Hazardous Materials Summary Table (HMST) product that must receive further approval through the Payload Safety Review Panel. The product must also be re-verified to have been met once all substances are loaded into your payload to verify the final flight product. NOTE: the payload is NOT allowed to exceed or add substances or concentrations from the Safety Reviewed version, only decreases can be made. The final sign-off to the HMST is called the "V-2". The Payload Provider will need to provide their final load values and sign-off. Voyager Exploration will forward the "V-1" (version from Safety Review) for mark-up ahead of flight loading.

The following are generic guidelines on what CANNOT be transported:

- No bio (health) hazard material rated higher than 2M
- No radioactive material
- No material/substance rated higher than a Toxicity Hazard Level 2
- No explosive gases/reactive mixes

NOTE: Payload Providers need to check that any chosen substance, or combination of substance, is compatible with the container material.

If you need help with checking any material for the above concerns, please send your questions to your Voyager Exploration point-of-contact.

4.1.4.1.1 Levels of Containment for Hazardous Chemicals and Biological Materials

Section 4.7.2 – Hazardous Materials, of SSP 51721, ISS Safety Requirements Document, Levels of Containment (LoC) for hazardous chemicals and biological materials are defined as:

> *…concentric independent layers (physical barriers) in the end item design where each individual layer is of a design integrity able to contain the hazardous material. The required number of independent levels of physical barriers is based on the hazard severity as identified above and is maintained throughout the flight.*
>
> *Each individual level of containment is required to be functionally separate, independent, and capable of containment (no leakage or erosion) under the worst-case conditions of use. Conditions of use, also referred to as environments, generally consist of all the environments that the end item will be exposed to, including handling, exposure durations, appropriate combinations of thermal, vibration, pressure (including module depressurization), mechanical, cycle life, and others as appropriate.*

Payloads containing materials (such as liquids, gases, gels, greases, powders, and/or particulates) that have been deemed hazardous by the JSC Toxicology and Microbiology group **shall** provide adequate levels of containment for the materials in question. Depending on the hazard level of the material documented in the payload HMST, the payload may need to use up to three independent levels of containment. Details on the levels of containment used are to be documented in the payload ICA.

The Payload Provider must provide a Certificate of Compliance for each independent seal/containment level and sanitization of the payload by the time the hardware is turned over to Voyager Exploration. The payload is to be turned over to Voyager Exploration in a sealed clear bag to allow for a visual inspection for a potential containment breach.

4.1.4.2 Flammability and Off-Gassing

Payloads **shall** complete the Bill of Materials (BOM) template (provided by Voyager Exploration) and submit it to Voyager Exploration Mission Management/Safety for assessment of structural materials for off-gassing and flammability.

4.1.5 Batteries

Payloads containing batteries **shall** comply with the requirements outlined in JSC 20739, Crewed Space Vehicle Battery Safety Requirements. Due to the unique nature of hazards presented by batteries and battery-powered payloads, detailed information about the battery power system design, cell chemistry, voltage, capacity, cell arrangement, and charge/discharge cycling must be provided to Voyager Exploration early in the development process.

Payloads containing real time clocks or requiring a battery to maintain volatile memory may use commercially available coin or button cell batteries provided they meet the Non-Critical Risk classification per JSC 20739. This lowest level of hazard control is reserved for low energy cells and battery designs for which standard emergency procedures are written and practiced. A battery is defined as one cell or an assembly of two or more cells. Payloads that require a battery in this context should use a battery that is UL listed and Payload Developers should provide details on all batteries and how the batteries are used in the ICA. The requirements for the Non-Critical Risk classification are listed below:

- Rated with a toxicological level of 1 or 2.
- Must not be contained in an intentionally sealed compartment.
- Meet one of the following chemistry criteria:
  - Alkaline or Silver Oxide non-rechargeable cells. Multiple cells may be used, but the cells must be arranged either all in parallel or all in series and the total battery must not exceed 12V and/or 60Wh capacity. There must be no potential charging source, and the cells must be located in a vented compartment.
  - Lithium non-rechargeable button cell batteries (only Li-MnO2, Li-CFX and LiFeS2) of up to 1000mAh capacity. Multiple cells may be used but must contain less than 4Wh total capacity.
  - Lithium-ion rechargeable button cell batteries of up to 1000mAh capacity. Multiple cells may be used but must contain less than 4Wh total capacity.

Batteries that do not meet the requirements listed above will be classified as Critical Risk or Catastrophic Risk. Approval of a battery system in these risk classifications is dependent upon hazard controls, design evaluation, testing, and verification. Evaluation of the battery system must be complete prior to certification for flight and ground operations. Due to the high risk of rejection for battery control system designs, Payload Providers are strongly encouraged to seek feedback from Voyager Exploration prior to committing to a battery system design and before manufacturing any battery system hardware. Consulting with Voyager Exploration prior to system development can save substantial cost and prevent schedule delays by ensuring a compliant design in the first iteration.

4.2 Payload Structural Requirements

4.2.1 Dimensions

The dimensions of a Black Box payload **shall** not exceed those shown in **Figure 4.2.1-1**.

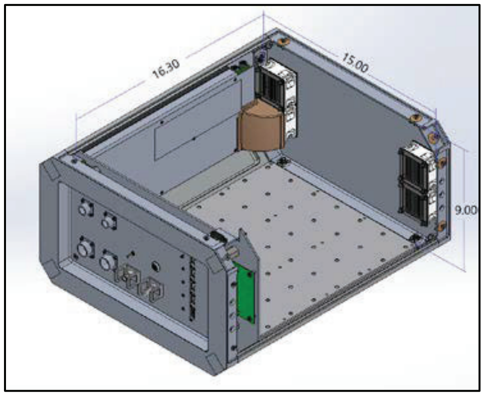

Figure 4.2.1-1 Bolt grid configuration work envelope.

4.2.2 Mass Properties

The mass of a payload within Black Box **shall** not exceed 18lbs. Larger payloads may be accommodated as negotiated and documented in a mission specific ICA.

4.2.3 Structural Analysis Factor of Safety (FOS)

Structural analysis performed to verify the requirements in the following sections **shall** apply a FOS of 1.5 (yield) and 2.0 (ultimate) and result in a positive margin of safety (>0.00).

The margin of safety must be calculated using the following formula:

Safety Margin = (Ultimate Tensile Strength / (FOS * Maximum Principle Stress)) – 1

4.2.4 Transportation Loads

4.2.4.1 Acceleration Loads

Payload safety-critical structures **shall** (and other payload structures *should*) provide positive margins of safety when exposed to the accelerations documented in **Table 4.2.4.1-1** at the center of gravity of the item, with all six degrees of freedom acting simultaneously. The acceleration values are applicable to both soft stowed and hard mounted hardware.

Table 4.2.4.1-1: Launch/Landing Load Factors Envelope
Ref SSP 57000, (57000-IRD-PIRN-0118A,) Table D.3.1.1-1

	Nx (Axial) (g)	Ny (Lateral) (g)	Nz (Lateral)(g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
Launch	**+/- 7.0**	**+/- 4.0**	**+/- 4.0**	**+/- 13.5**	**+/- 13.5**	**+/- 13.5**
Landing	**+/- 9.2**	**Lateral RSS (Ny & Nz) +/- 9.3**		**N/A**	**N/A**	**N/A**

Note: For each load case, the maximum combined loads must be applied in all directions and all permutations of positive and negative loads in each direction must be covered

4.2.4.2 Random Vibration Loads

Payload vibration sensitive safety-critical structures that are packed in foam or bubble wrap and either soft stowed in bags or enclosed in hard containers such as lockers, boxes, or similar structures **shall** meet the specified performance requirements when exposed to the maximum flight random vibration environments defined in **Table 4.2.4.2-1**.

Random vibration testing may not be required; coordination with the Safety and Interface verification groups may allow this to be reduced to the leak testing already required of any containment level(s). If considering the testing, the standard stowage configuration is the payload wrapped in bubble wrap. Otherwise, test to the stowage requirements as set in the payload ICA.

Table 4.2.4.2-1: Random Vibration Environment
Ref. SSP 57000, (57000-IRD-PIRN-0128A), Rev T, Table D.3.1.2-1

FREQUENCY (Hz)	PROTOFLIGHT TEST LEVEL (g^2/Hz)
20	0.35
100	0.35
100 - 160	-13.85 dB/octave slope
160 - 500	0.04
500-2000	-3 dB/octave slope
2000	0.01
Overall	8.8 g_{rms}
Duration	1 min/axis

NOTE: Per NASA-STD-7001, Appendix B, the MWL portion of the protoflight test level may be adjusted at the 160-500 Hz plateau level for items weighing between 110 pounds (50 kg) and 440 pounds (200 kg).

4.2.4.3 Shock Loads

Integrated end items packed in the foam or bubble wrap materials do not experience significant mechanical shock. Shock verification is not required for launch events. If the payload uniquely has any mechanical or electrical components that are highly sensitive to shock, these should be assessed on a case-by-case basis as defined in the payload ICA.

4.2.5 IVA Loads

4.2.5.1 Crew Induced Loads

Generally, all payloads should be designed to provide positive margins of safety when exposed to the crew induced loads defined in **Table 4.2.5.1-1**. However, items inside Black Box may exempt from this requirement due to no direct crew interface.

Table 4.2.5.1-1 Crew-Induced Loads
Ref SSP 57000, Rev T, Table 3.1.1.1.2-1

CREW SYSTEM OR STRUCTURE	TYPE OF LOAD	LOAD	DIRECTION OF LOAD
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Small Knobs	Twist (torsion)	14.9 N-m (11 ft-lbf), limit	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	222.6 N (50 lbf)	Any direction
Rack front panels and any other normally exposed equipment	Load distributed over a 4 inch by 4 inch area	556.4 N (125 lbf), limit	Any direction
Legend: ft = feet, m = meter, N = Newton, lbf = pounds force			

4.2.5.2 Station Re-Boost Loads

Payloads **shall** be designed to have positive margins of safety for on–orbit loads of 0.2 g acting in any direction for nominal on-orbit operations.

4.2.5.3 Microgravity Disturbance Requirements

All Black Box payloads **shall** limit the force and vibrations they induce into Black Box such that they do not exceed the EXPRESS Rack vibratory limits shown in **Figure 4.2.5.3-1** and the transient force limit of 10 lb·s (44.5 N·s) over a ten-second period. Any moving parts within the payload (especially motors, pumps, valves, etc.) must be assessed. If sufficient manufacturer data for the motors, pumps, etc., is available to verify the payload is within limits, an analysis may be performed to show that the payload is within the required limits. Otherwise testing must be completed to verify compliance.

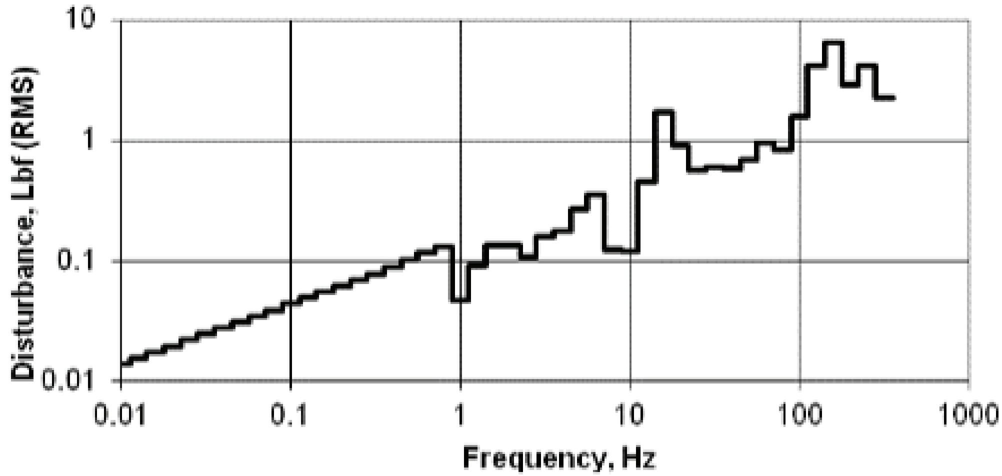

Figure 4.2.5.3-1: Express Rack Subrack Payload Vibratory Disturbances Allowable
Ref SSP 57000, Rev T, Figure F.3.1.3.2-1

4.3 Acoustic Requirements

Any payload with a motor or device that can create acoustic noise **shall** be tested to meet acoustic limits that were set by the Program to both protect the crew and prevent negative impact to other payloads/equipment.

If the payload's source of noise exists for a cumulative total of more than eight hours in any 24-hour period, it is considered a continuous noise, but must also meet the intermittent noise limits. If less, only the intermittent noise needs to be evaluated. Therefore, the noise duration is to be specified in the ICA. The payload should be designed as not to exceed the intermittent and continuous acoustic limits shown in **Table 4.3-1** and **Table 4.3-2**.

Table 4.3-1: Intermittent Noise Limits
Ref SSP 57000, Rev T, Table 3.12.3.2-1

Noise Limits Measured at 0.6 Meters Distance from the Test Article	
Maximum Noise Duration Per 24 Hour Period	**Total A-weighted Overall SPL (dBA)**
A	B
≤ 8 Hours	49
7 Hours	50
6 Hours	51
5 Hours	52
4.5 Hours	53
4 Hours	54
3.5 Hours	55
3 Hours	57
2.5 Hours	58
2 Hours	60
1.5 Hours	62
1 Hour	65
30 Minutes	69
15 Minutes	72
5 Minutes	76
2 Minutes	78
1 Minute	79
Not Allowed	80

The Noise Duration is the total time that the payload produces intermittent noise above its continuous noise requirement limit during a 24 hour time period (see Figure 3.12.3.2-2). This duration is the governing factor in determining the allowable Intermittent Noise Limits. Multiple sources within an integrated rack are considered as separate sources and can operate during the same 24-hour period.

Table 4.3-2: Continuous Noise Limits
Ref SSP 57000, Rev **T**, Table G.3.12.1-1

Noise Limit at 0.6 Meters Distance From Equipment (NC 34)	
Frequency Band (Hz)	**SPL (dB)**
63	59
125	52
250	45
500	39
1000	35
2000	33
4000	32
8000	31

4.4 Payload Electrical and Data Interfaces

Black Box can provide electrical power and USB 3.0 data connections for up to 12 individual payloads. Each USB 3.0 interface to the payload can provide 5 VDC at 2 Amps. Each of the auxiliary power ports can provides 5 volts at 5 Amps and 12 volts at 3 Amps. Payloads may use any combination of power sources within the restrictions outlined in the subsequent sections of this document.

Payloads can use the USB 3.0 data connection to allow for remote access to their payload via serial over USB or ethernet over USB protocols. Voyager Exploration Operations Engineers can use this connection to operate a payload, download data from a payload, or to update operating parameters or scripts for the payload. Black Box also offers up to 2TB of data storage for payloads that need to generate videos or other large data files but might not have sufficient internal storage to hold them. Files can be offloaded to the Black Box data storage drives and retrieved when the payloads return to earth.

4.4.1 Electrical Interface

4.4.1.1 USB Interface

The payload **shall** meet the USB 2.0, or USB 3.0 standard. The USB ports provide 5VDC at up to 2A of current. If there is an overcurrent event, the current limiter will hold the output current at 2A and reduce the output voltage commensurately. If the overcurrent event is sustained, a thermal shutdown will occur, and the USB port will be turned off. The USB port can be reactivated by Voyager Exploration Operations if no hazards exist. A pinout for a standard USB Type A plug is provided in **Figure 4.4.1.1-1**.

		USB 3.0 Type A Connector Pinout		
		Pin	Signal	Wire Color
USB 3.0	USB 2.0	1	VBUS	Red
		2	D-	White
		3	D+	Green
		4	GND	Black
		5	StdA_SSRX-	Blue
		6	StdA_SSRX+	Yellow
		7	GND_DRAIN	Bare
		8	StdA_SSTX-	Purple
		9	StdA_SSTX+	Orange
		Shell	Shield	Braid

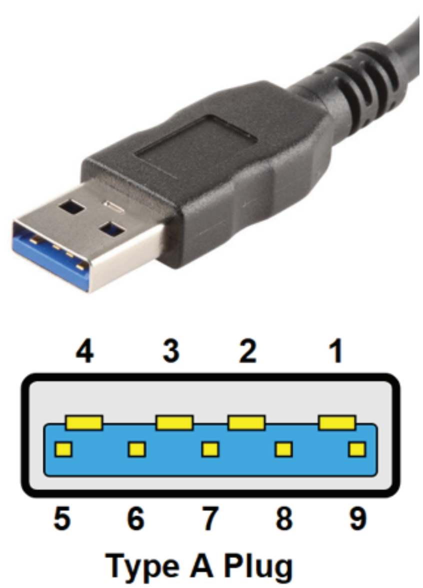

Figure 4.4.1.1-1 USB Type A Plug

4.4.1.2 Auxiliary Power Interface

The 5V and 12V Auxiliary power ports can be used if a payload requires more power than the USB ports can provide. The 5V Aux power can provide up to 5A of current to a payload, and the 12V Aux power can provide up to 3A of current to a payload. The Aux power sources may be used in conjunction with the USB power and each other but must remain electrically isolated from all other power sources. Current limiters for the Aux power ports are fast acting and shut off power to the port within 1ms of an exceedance. Payload developers should design their payloads to limit inrush current to prevent inadvertent tripping of the current limiters upon payload power on. A Pinout for the Aux power connector is shown in **Figure 4.4.1.2-1**, and the part numbers for the connector and contacts can be found in **Table 4.4.1.2-1.**

Aux Power Connector	
Pin	Function
1	12V Return
2	Shield
3	5V Return
4	+12V
5	Shield
6	+5V

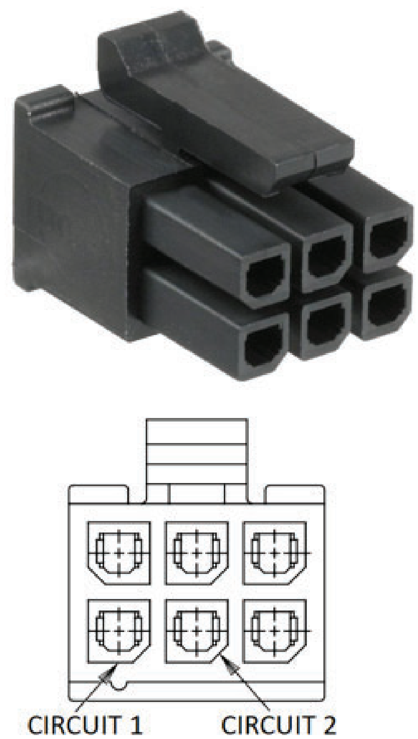

Figure 4.4.1.2-1 Black Box Aux Power Payload Side Connector

Table 4.4.1.2-1 Aux Power Connector Part Numbers

Part Number	Description
430250600	Micro-Fit 3.0 Receptacle Housing, Dual Row, 6 Circuit
430300002	Micro-Fit 3.0 Crimp Terminal, Female, with Select Gold (Au) Plated Phosphor Bronze Contact, 20-24 AWG
430300005	Micro-Fit 3.0 Crimp Terminal, Female, with Select Gold (Au) Plated Phosphor Bronze Contact, 26-30 AWG
430300039	Micro-Fit 3.0 Crimp Terminal, Female, with Select Gold (Au) Plated Phosphor Bronze Contact, 18 AWG

4.4.2 Electrical Compliance

4.4.2.1 Grounding, Bonding and Electrical Isolation.

All powered payloads **shall** comply with the Power Isolation, Single Point Ground, and Bonding requirements listed below. Verification of grounding, bonding, and isolation **shall** be by test and will be verified by Voyager Exploration prior to integration, functional checkout and operation at our Webster, TX facility. Payloads failing to meet these requirements will be rejected until they meet the requirements listed.

4.4.2.2 Power Isolation

Each electrical power source **shall** be DC isolated from all other power sources and the payload structure and shield connections by a minimum of 1 Megaohm resistance. Power sources cannot be electrically tied together, i.e., 5V USB power cannot be connected to 5V Aux power. These power channels are switched independently and have independent current limiting devices. Similarly, payloads that use multiple payload positions cannot tie power channels together across payload positions, i.e., a payload may use the 12V Aux power from position 1 to power a computer, and simultaneously use the 12V Aux power from position 2 to operate an actuator, but the two circuits must be electrically isolated from each other. These power sources may be used simultaneously to power independent and isolated circuits, but they cannot be used in parallel to increase the current supplied to a single circuit.

4.4.2.3 Single Point Ground

The ISS utilizes a single point ground scheme; power returns must remain isolated from structure all points except the power source. It is important to delineate the colloquial usage of “ground” from the defined uses in space flight hardware. The terms “power return”, or simply “return” describe the intended and discrete current source path designed for the payload. The terms “structure”, “case”, or “shield” describe the conductive elements of the payload structure and braided shielding on electrical cables. Electrical current is not permitted to flow through the ISS structure or cable shields except in fault conditions.

Power returns for the 5V USB, 5V Aux Power and 12V Aux Power **should** be isolated from each other. Failure to isolate the returns may cause a ground loop and interference in the payloads. Each electrical power source utilized by the payload **shall** utilize its associated power return. For example, if both the 5V Aux power and 12V Aux power sources are used by the payload, the power returns cannot be tied together to a single wire and connected to just a single pin on the Aux power connector. Both returns must be used to prevent overloading of a single connector pin.

All power returns **shall** be DC isolated from the payload structure and shield connections by a minimum of 1 Megaohm resistance. Many commercial electronics used in payloads connect mounting pads or cable shields to the power return. The payload developer must ensure that these connections are properly isolated from the payload structure by either severing the cable shields, modifying the PCB, or using non-conductive mounting hardware as required.

4.4.2.4 Electrical Bonding

A class H bond is required for all exposed conductive structures to prevent a shock hazard in the event a fault condition allows current to flow through the structure. The bonding path for Black Box payloads is provided through the shield pins on the connectors and through the bolted interface to the baseplate. The payload bond will be tested prior to integration into Black Box for functional testing.

Payloads utilizing metal enclosures, or with exposed conducting surfaces **shall** have less than 0.1 Ohm resistance from the enclosure or each exposed conducting surface to the shield pin(s) on the electrical connectors or to the Black Box baseplate when bolted in place. Two shield pins are provided in the Aux power connector. The USB cable shield may be used for bonding, but payload developers should be aware that most commercially available USB devices tie the shield on the cable to the power return plane on the device and thus violate the single point ground requirements in section 4.2.2.3.

Payloads with bolted interfaces between exposed conducting surfaces may use a bonding jumper or faying surfaces to create the bond path between the structures. Bonding jumpers must be sized to carry the worst-case fault current that could occur; generally, the worst-case fault current is considered to be 130% of the upstream circuit protection value. Payloads that utilize a faying surface between the two conductive parts or depend upon the bond between the structure and the base plate of Black Box must have a conducting contact area at least 4 times greater than the cross-sectional area of a wire sized to carry the worst-case fault current. An example calculation is demonstrated below.

Bonding Example:

For a circuit utilizing a 4-amp fuse:

Maximum fault current is 130% of fuse rating:

$$4A * 130\% = 5.2A$$

Minimum bonding wire size required:

24AWG - 175°C Rate TFE Insulated wire

Minimum faying surface contact area:

24AWG wire diameter: 0.0201”

Faying Surface Conductive contact area:

$$(0.0201in / 2)^2 * \pi * 4 = 0.0013in^2$$

4.4.2.5 Wire Derating

Internal payload wiring **shall** be derated per **Table 4.4.2.5-1**. Additionally, **Table 4.4.2.5-2** is provided to inform the payload developer of the maximum current carrying capability of each wire gauge. Exceeding the current limits specified in **Table 4.4.2.5-2** will cause pyrolyzation of the payload wiring.

To ensure adequate safety margins, wire gauges smaller than 24 AWG are not recommended. Payloads requiring wire gauges smaller than 24 AWG will require analysis and coordination with NASA to approve. Any payload wiring smaller than 24 AWG should be declared on the ICA. Every effort should be made to use TFE or PTFE insulated wire with 200°C temperature rating in the payload.

Most commonly available wire uses PVC insulation. PVC wire insulation is flammable and generally not permitted. If the use of PVC wire is unavoidable, then the total length of PVC insulated wire in the payload must not be longer than 6 inches. Often the use of PVC insulation found on or in off-the-shelf cables (USB, HDMI, SATA, etc.) is unavoidable. In these cases, the wire must be securely and completely wrapped in Teflon tape and documented on technical drawings and BOMs. If payload providers cannot positively identify the wire insulation, they must assume the wire is PVC insulated, and they should identify it on the ICA.

Table 4.4.2.5-1 Single Wire IVA Derating Criteria

Ref SSP 51721, Rev -, Table 4.3.1.2-1

TABLE 4.3.1.2-1 WIRE SIZE DERATING AND CIRCUIT PROTECTION

	Column A		Column B		Column C
	Maximum Continuous Current Rating (100% of Circuit Protection Rating)		130% of Circuit Protection Rating (or worst-case upstream current >1 second)		Current Limits to meet touch temperature limited for crew accessible wire/cables
	IVA	EVA	IVA	EVA	IVA
Wire Size (AWG)	Upstream Current Protection Limit for a Single Wire (I_{sw}) (amps) [1, 2, 3.7]	Upstream Current Protection Limit for a Single Wire (I_{sw}) (amps) [1, 5,6,7]	Maximum Allowed Smart Short Current (amps) [1, 2, 4]	Maximum Allowed Smart Short Current (amps)[1, 4, 5]	Maximum Wire Current < 45C/113F[,7]
26	3.8	3.4	4.9	4.4	1.7
24	5.4	4.7	7.0	6.1	2.7
22	7.4	6.5	9.6	8.4	3.5
20	10.0	8.8	13.0	11.4	4.8
18	13.2	11.6	17.2	15.1	6.0
16	15.0	13.3	19.5	17.3	7.6
14	20.0	18.0	26.0	23.4	9.5
12	29.0	25.0	37.7	32.5	12.8
10	40.0	34.8	52.0	45.2	17.7
8	63.0	56.0	81.9	72.8	29.7
6	92.0	80.0	119.6	104.0	43.1
4	120.0	110.0	156.0	143.0	58.6
2	170.5	150.5	221.6	195.6	90.9
1/0	260.0	220.5	338.0	286.6	108

Note 1 – Wire size deratings listed are for wire insulation rated for 200°C.
Note 2 - These currents are for Intravehicular Activities (IVA) wires on-orbit in cabin ambient at 22°C (72°F).
Note 3 – IVA Wire with these currents will reach 118°C (242°F). The wires are not to be accessible to the crew. For IVA crew accessible wires, use Column C.
Note 4 - This current is the maximum sustained fault current allowable by the circuit protection device. Wire temperature could reach 185°C (365°F).
Note 5 - These currents are for IVA wires in a vacuum at 94°C (200°F) ambient.
Note 6 - Wire with these currents will reach 147°C (295°F) and are not to be accessible to the IVA crew.
Note 7 –It is necessary that wire bundle derating account for maximum continuous current rating and current limits.
Note 8 - Bundle derating may not be necessary if bundled power wiring is not significantly loaded. When wire is bundled, maximum design current for each individual wire is derated according to the following:
For N < 15 For N > 15
Bundled Wire (IBW) = Single Wire (ISW) × (29 - N)/28 IBW = (0.5) × ISW
Where: N = number of wires IBW = current, bundle wire
rent, single wire

Table 4.4.2.5-2 Wire Sizing Criteria
Ref SSP 57000, Rev T, Table 3.2.1.2.2-2

Wire Gauge	150 °C Wire Rating	175 °C Wire Rating	200 °C Wire Rating
0	310.0	335.0	361.1
2	205.0	225.0	245.8
4	140.0	153.0	171.6
6	107.0	118.0	128.9
8	74.0	82.0	88.4
10	47.5	52.0	56.2
12	34.0	37.0	40.9
14	23.5	25.7	28.7
16	17.4	19.1	21.4
18	15.8	17.4	19.1
20	11.7	12.8	13.9
22	8.7	9.5	10.4
24	6.3	6.8	7.5
26	4.4	4.9	5.3

Notes:

1. Wire rating information is derived from extensive testing of MB0150-048 Orbiter wiring at JSC and applies to equivalent copper wiring with any type of insulation. For convenience, information pertaining to wire with insulation ratings of 150 °C, 175 °C, and 200 °C are shown. For wire ratings other than these, refer to JSC engineering publication TM 102179, "Selection of Wires and Circuit Protection Devices for NSTS Orbiter Vehicle Payload Electric Circuits". Wire sizes smaller than 26 gauge are not recommended for use in payloads.
2. An ambient temperature of 22.2 °C is assumed for pressurized locations.
3. Current Carrying Capacity of Wire – Represents the maximum sustained current in amperes which the wire can carry in the specified environment and not experience a temperature that exceeds the temperature rating of the insulation material.
4. This table does not reflect wire bundle derating, nor does NASA JSC believe bundle derating to normally be necessary. This is due to the multitude of inter-related factors involved in bundling which can either enhance or degrade the current-carrying capacity of wire. However, in unique applications where a majority of wires in a bundle are heavily loaded simultaneously, the user may utilize the wire bundle criteria of Table 3.2.1.2.2-1, Note 8.

4.4.2.6 Circuit Protection Devices

Overcurrent protection **shall** be provided at all points in the system where power is distributed to lower level and **shall** be derated according to **Table 4.4.2.6-1** and **Table 4.4.2.6-2**. Fuses and circuit breakers are thermal devices and the lack of natural convection and normal heat dissipation in the microgravity environment causes additional thermal stress on these devices. Fuses and circuit breakers must be derated, or oversized, to ensure they do not trip at a lower current limit than anticipated. Wiring and circuit traces must be sized appropriately for the circuit protection device. For example, a circuit nominally requires a 4A fuse and 24AWG wire, but fuse derating requires the fuse size to be increased to 8A, then the wire will have to be increased to 20AWG to account for the higher capacity circuit protection.

Table 4.4.2.6-1 Fuse Derating
Ref SSP 57000 3.2.1.2.1-1

Fuse current Rating (amperes)	Derating Factor (1) (2)	Remarks
2 - 15	0.50	Fuses are derated by multiplying the rated amperes by the appropriate Derating Factor listed. Rating at 25 °C ambient. Derating of fuses allows for loss of pressure, which lowers the blow current rating and allows for a decrease of current capability with time.(1)(3)
1 & 1.5	0.45	
0.5 & 0.75	0.40	
0.375	0.35	
0.25	0.30	
0.125	0.25	

(1) If calculations result in fractional values, use the next highest standard fuses rating.
(2) Derating factors are based on data from fuses mounted on printed circuit boards and conformally coated. For other types of mounting, consult the project parts engineer for recommendations.
(3) For cartridge style fuses or any fuses that are not heatsinked, an additional derating of 0.5 percent/°C above 25 °C ambient is required.

Fuse Derating Example:

The principal stress parameter is current:

A board expected to be operating at 90 °C ambient has a calculated maximum current of 1.0 A. The additional derating required due to temperature is calculated as shown:

$$\frac{0.5\%}{°C} \times (90\ °C - 25\ °C) = 32.5\%$$

The total derating factor is calculated as follows:

$$50\% - 32.5\% = 17.5\%$$

The fuse rating is calculated as shown:

$$\frac{1.0\ A}{0.175} = 5.7\ A$$

A fuse with rating equal to or greater than 5.7 A is suitable in this circuit.

Table 4.4.2.6-2 Circuit Breaker Derating
From SSP 57000 3.2.1.2.1-2

Contact Application	Contact Derating Factor	Maximum Device Thermal Rating
Resistive	0.75	20 °C above the specified operating temperature range
Capacitive	0.75(1)	
Inductive	0.40	
Motor	0.20	
Filament	0.10	
Circuit breaker contacts are derated by multiplying the maximum rated contact current (resistive) by the appropriate contact derating factor. (1) Use series resistance to ensure that circuits do not exceed the derated level.		

Circuit Breaker Derating Example:

The principal stress parameter is contact current.
A circuit breaker is to be selected to control an electrical motor rated at 17 A, full load, 24 Vdc. The circuit breaker is to be installed in an environment with an ambient temperature ranging from 10 °C to 30 °C.
The temperature derating is:

$$30\ °C + 20\ °C = 50\ °C$$

The contact current derating is:

$$\frac{17\ A}{0.20} = 85\ A$$

This example, then, requires the use of a circuit breaker with a maximum thermal rating equal to or greater than 50 °C and a maximum contact rating of at least 85 A for this application.

4.4.2.7 EMI

Payloads connecting to any power source or that are battery powered **shall** comply with the radiated emissions (RE) (RE02) limits defined in SSP 30237, paragraph 3.2.3.1.2.1, at 100 MHz and higher frequencies. Payloads must meet this requirement when integrated within the Black Box.

Payload safety-critical circuits that are connected to any power source or that are battery powered **shall** meet the radiated susceptibility (RS) 03 limits defined in SSP 30237, paragraph 3.2.4.2.2, at 100 MHz and higher frequencies. Non-safety-critical circuits *should* meet the radiated susceptibility (RS) 03 limits defined in SSP 30237, paragraph 3.2.4.2.2, at 100 MHz and higher frequencies.

4.5 Command and Data Interfaces

Payloads that require data handling must adhere to interface requirements with the Black Box regarding the timing and availability of the payloads mass storage devices. The ability of the payload to appear as a mass storage device allows Voyager Exploration to verify successful connection of the payload to Black Box and ensure uninterrupted file transfers between the payload and Black Box. If a payload requires data handling, it must meet the following requirements to ensure this communication:

- The payloads shall make its memory available to the Black Box system for at least 30 minutes after power up and shall not be actively using that memory during that time. This time will be used to verify good connection/access between Black Box and payload(s) and perform any actions needed prior to experiment execution.
- The Payload shall make its mass storage memory available for access periodically in order for experiment data to be downlinked to the ground. The time period when the drive becomes accessible is dependent on the payload and the requirement on how often files must be downlinked. Payload may use clocks, timers, or any other trigger to implement this periodic access as negotiated by the ICA. For each access window, the drive should remain open for at least 1 hour. The timing of the access windows will be assessed on a case-by-case basis as defined in the payload ICA.

For downlink of experiment data to the ground, the nominal downlink capability is approximately 1 GB per day. If Payload requires additional downlink capacity, that must be negotiated as part of the ICA

4.6 Payload Environments

4.6.1 Thermal Environment

Expected thermal environments for all phases of payload integration are summarized in **Table 4.6.5-1** Expected Thermal Environments. Payloads with special thermal constraints should coordinate with Voyager Exploration.

Table 4.6.5-1: Expected Thermal Environments
Ref SSP 50835, Table E.2.10-1

Ground Transport (Customer facility to Voyager Exploration)	Determined for each payload
Ground Processing Voyager Exploration	Determined for each payload
Ground Processing NASA	10°C to 35°C (50°F to 95°F)
Pressurized Cargo Vehicle	
Dragon Pressurized Cargo	18.3°C to 29.4°C (65°F to 85°F)
Cygnus Pressurized Cargo	10°C to 46°C (50°F to 115°F)
On-orbit, Pre-deployment, U.S. and JEM Modules	16.7°C to 28.3°C (62°F to 83°F)
On-orbit, EVR deployment	To be analyzed by payload developer per ICA

Payloads shall be designed to not exceed a touch temperature of 45° C. A thermal analysis is required for payload heat release to the cabin.

4.6.2 Humidity

The relative humidity will be 25% to 75% RH for ascent and on-orbit phases of flight. Payloads with special humidity control requirements should coordinate with Voyager Exploration.

4.7 HFIT (Human Factors Implementation Team) Requirements

Generic guidance is provided to the User to ensure compliance to ISS Program HFIT requirements. Voyager Exploration reviews the Payload design. Dependent on Payload design, unique requirements may be levied through the ICA between Voyager Exploration and the User.

4.7.1 Recommended Compliance Methods and Best Practices

The following are recommended compliance methods and best practices to meet requirements. This information is representative of acceptable methods approved by NASA HFIT to date. Contact Voyager Exploration for specific guidance.

4.7.1.1 Protuberances, Deployable Elements and Appendages

Reserved

4.7.1.2 Surface Requirements Compliance

Burrs and sharp edges shall be removed by a process that leaves a radius, chamfer, or equivalent between 0.005in and 0.015in. Gauges not are not required. If radius or chamfer methods cannot be used then consider using covers

4.7.1.3 Securing Cables

Use of nylon locking “zip” ties or cable clamps as shown in **Figure 4.7.1.3-1** are examples of approved methods for securing cables in Black Box payloads.

Figure 4.7.1.3-1: Example Applications of Zip ties and Cable Clamps

4.8 Customer Deliverables

Table 4.8-1 describes the list of potential customer deliverables required to certify the payload for flight. More detailed information will be outlined in the payload ICA.

Table 4.8-1: Deliverables

Item	Deliverable	Description	Date
1	Bill of Materials	Complete BOM required; if complete with amounts and accurate with material/vendor data – out-gas testing is generally met by Program assessment rather than testing.	NLT-4M
2	Data for Tox/Bio Hazard Evaluation		NLT L-4M
3	MSDSs for each substance		NLT L-4M
4	Final mass and dimension report		NLT H/W Turn-over
5	Containment Level & Cleanliness Certification	Certificate of Compliance for Containment Levels and Sanitized Surface required for turn-over/handling acceptance or leak and vibration testing (if required)	NLT H/W Turn-over
6	Quality Assurance Certification	COC stating that the hardware was built, assembled, and meets the ICA; final mass/dimension report; Certifications and BOM provided.	Hardware Delivery

5 Requirements Matrix

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1	**Safety Requirements**			**NVR**	
4.1.1	**Safety Criticality Definitions**			**NVR**	
4.1.2	**Debris and Shatterable Materials**	Payloads **shall not** generate debris during launch or normal mission operations.	**A**	**I**	**CoC**
4.1.2.1	**Shatterable Materials**	If the hardware contains shatterable materials, the hardware **shall** provide containment to ensure that no particles 50-micron or larger are liberated.	**A**	**I**	**Drawings**
4.1.2.2	**Rotating Equipment**	Hardware containing rotating equipment shall provide containment such that no rotating parts can be liberated from the payload AND any rotating components shall be less than 200 mm in diameter and rotate at less than 8000 RPM max.	**A**	**I**	**Drawings**
4.1.3	**Pressure Systems**	Payloads with pressurized gas systems which have a total expanded gas volume exceeding 400 liters at Standard Conditions **shall** limit the gas flow after a single failure to less than 240 SLPM after 400 liters at Standard Conditions has been released to the cabin air. This applies to payloads for both on-orbit and transport time periods.	**A**	**A**	**Analysis**
4.1.4	**Hazardous Materials**			**NVR**	
4.1.4.1	**Toxicology and Microbiology**	Payloads **shall** pass a JSC Toxicology and Microbiology Review. The assessment by the two groups is established as the Hazardous Materials Summary Table (HMST) product that must receive further approval through the Payload Safety Review Panel.	**A**	**I**	**HMST Report**
4.1.4.1.1	**Levels of Containment**	Payloads containing materials (such as liquids, gases, gels, greases, powders, and/or particulates) that have been deemed hazardous by the JSC Toxicology and Microbiology group **shall** provide adequate levels of containment for the materials in question. Depending on the hazard level of the material documented in the payload HMST, the payload may need to use up to three independent levels of containment.	**A**	**I, A**	**Drawings and HMST Report**

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1.4.1.2	**Flammability and Off-Gassing**	Payloads **shall** complete the Bill of Materials (BOM) template (provided by Voyager Exploration) and submit it to VE Mission Management/Safety for assessment of structural materials for off-gassing and flammability.	**A**	**I**	**BOM**
4.1.5	**Batteries**	Payloads containing batteries **shall** comply with the requirements outlined in JSC 20739, Crewed Space Vehicle Battery Safety Requirements. Due to the unique nature of hazards presented by batteries and battery-powered payloads, detailed information about the battery power system design, cell chemistry, voltage, capacity, cell arrangement, and charge/discharge cycling must be provided to VE early in the development process.	**A**	**I**	**Battery Report**
4.2	**Structural Requirements**			**NVR**	
4.2.1	**Dimensions**	The dimensions of a Black Box payload **shall** not exceed those shown in **Figure 4.2.1-1**.		**I**	**Drawings**
4.2.2	**Mass Properties**	The mass of a payload within Black Box **shall** not exceed 18lbs. Larger payloads may be accommodated as negotiated and documented in a mission specific ICA.	**A**	**I**	**Mass Report**
4.2.3	**Structural Analysis FOS**	Structural analysis performed to verify the requirements in the following sections **shall** apply a FOS of 1.5 (yield) and 2.0 (ultimate) and result in a positive margin of safety (>0.00).	**A**	**A**	**Structural Report**
4.2.4	**Transportation Loads**			**NVR**	
4.2.4.1	**Acceleration Loads**	Payload safety-critical structures **shall** (and other payload structures *should*) provide positive margins of safety when exposed to the accelerations documented in **Table 4.2.4.1-1** at the center of gravity of the item, with all six degrees of freedom acting simultaneously. The acceleration values are applicable to both soft stowed and hard mounted hardware.	**A**	**A**	**Structural Report**
4.2.4.2	**Random Vibration Loads**	Payload vibration sensitive safety-critical structures that are packed in foam or bubble wrap and either soft stowed in bags or enclosed in hard containers such as lockers, boxes, or similar structures **shall** meet the specified performance requirements when exposed to the maximum flight random vibration environments defined in **Table 4.2.4.2-1**.	**A**	**A**	**Structural Report**
4.2.4.3	**Shock Loads**			**NVR**	
4.2.5	**IVA Loads**			**NVR**	

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.2.5.1	**Crew Induced Loads**	Generally, all payloads should be designed to provide positive margins of safety when exposed to the crew induced loads defined in **Table 4.2.5.1-1**. However items inside Black Box may exempt from this requirement due to no direct crew interface.	**A**	**A**	**Structural Report**
4.2.5.2	**Station Re-Boost Loads**	Payloads **shall** be designed to have positive margins of safety for on–orbit loads of 0.2 g acting in any direction for nominal on-orbit operations.	**A**	**A**	**Structural Report**
4.2.5.3	**Microgravity Disturbance**	All Black Box payloads **shall** limit the force and vibrations they induce into Black Box such that they do not exceed the EXPRESS Rack vibratory limits shown in **Figure 4.2.5.3-1** and the transient force limit of 10 lb·s (44.5 N·s) over a ten-second period. Any moving parts within the payload (especially motors, pumps, valves, etc.) must be assessed. If sufficient manufacturer data for the motors, pumps, etc., is available to verify the payload is within limits, an analysis may be performed to show that the payload is within the required limits. Otherwise testing must be completed to verify compliance.	**A**	**T**	**Vibration Test**
4.3	**Acoustic Requirements**	Any payload with a motor or device that can create acoustic noise **shall** be tested to meet acoustic limits that were set by the Program to both protect the crew and prevent negative impact to other payloads/equipment.	**A**	**T**	**Acoustic Test**
4.4	**Electrical Requirements**			**NVR**	
4.4.1	**Electrical Interface**			**NVR**	
4.4.1.1	**USB Interface**	The payload **shall** meet the USB 2.0, or USB 3.0 standard. The USB ports provide 5VDC at up to 2A of current. If there is an overcurrent event, the current limiter will hold the output current at 2A and reduce the output voltage commensurately. If the overcurrent event is sustained, a thermal shutdown will occur, and the USB port will be turned off. The USB port can be reactivated by Voyager Exploration Operations if no hazards exist. A pinout for a standard USB Type A plug is provided in **Figure 4.4.1.1-1**.	**A**	**I**	**Drawings**

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.1.2	**Auxiliary Power Interface**	The 5V and 12V Auxiliary power ports can be used if a payload requires more power than the USB ports can provide. The 5V Aux power can provide up to 5A of current to a payload, and the 12V Aux power can provide up to 3A of current to a payload. The Aux power sources may be used in conjunction with the USB power and each other but must remain electrically isolated from all other power sources. Current limiters for the Aux power ports are fast acting and shut off power to the port within 1ms of an exceedance. Payload developers should design their payloads to limit inrush current to prevent inadvertent tripping of the current limiters upon payload power on. A Pinout for the Aux power connector is shown in **Figure 4.4.1.2-1**, and the part numbers for the connector and contacts can be found in **Table 4.4.1.2-1.**	**A**	**I**	**Drawings, Power Report**
4.4.2	**Electrical Compliance**			**NVR**	
4.2.2.1	**Grounding, Bonding and Electrical Isolation**	All powered payloads **shall** comply with the Power Isolation, Single Point Ground, and Bonding requirements listed below. Verification of grounding, bonding, and isolation **shall** be by test and will be verified by Voyager Exploration prior to integration, functional checkout and operation at our Webster, TX facility. Payloads failing to meet these requirements will be rejected until they meet the requirements listed.	**A**	**T**	**EMI/EMC Test**
4.4.2.2	**Power Isolation**	Each electrical power source **shall** be DC isolated from all other power sources and the payload structure and shield connections by a minimum of 1 Megaohm resistance. Power sources cannot be electrically tied together, i.e., 5V USB power cannot be connected to 5V Aux power. These power channels are switched independently and have independent current limiting devices. Similarly, payloads that use multiple payload positions cannot tie power channels together across payload positions, i.e., a payload may use the 12V Aux power from position 1 to power a computer, and simultaneously use the 12V Aux power from position 2 to operate an actuator, but the two circuits must be electrically isolated from each other. These power sources may be used simultaneously to power independent and isolated circuits, but they cannot be used in parallel to increase the current supplied to a single circuit.	**A**	**T**	**Magnetic Test**

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.2.3P	**Single Point Ground**	Power returns for the 5V USB, 5V Aux Power and 12V Aux Power **should** be isolated from each other. Failure to isolate the returns may cause a ground loop and interference in the payloads. Each electrical power source utilized by the payload **shall** utilize its associated power return. For example, if both the 5V Aux power and 12V Aux power sources are used by the payload, the power returns cannot be tied together to a single wire and connected to just a single pin on the Aux power connector. Both returns must be used to prevent overloading of a single connector pin. All power returns **shall** be DC isolated from the payload structure and shield connections by a minimum of 1 Megaohm resistance. Many commercial electronics used in payloads connect mounting pads or cable shields to the power return. The payload developer must ensure that these connections are properly isolated from the payload structure by either severing the cable shields, modifying the PCB, or using non-conductive mounting hardware as required.	**A**	**T**	**Grounding /Bonding Test**
4.4.2.4	**Electrical Bonding**	Payloads utilizing metal enclosures, or with exposed conducting surfaces **shall** have less than 0.1 Ohm resistance from the enclosure or each exposed conducting surface to the shield pin(s) on the electrical connectors or to the Black Box baseplate when bolted in place. Two shield pins are provided in the Aux power connector. The USB cable shield may be used for bonding, but payload developers should be aware that most commercially available USB devices tie the shield on the cable to the power return plane on the device and thus violate the single point ground requirements in section 4.2.2.3.	**A**	**T**	**Isolation test**
4.4.2.5	**Wire Derating**	Internal payload wiring **shall** be derated per **Table 4.4.2.5-1**. Additionally, **Table 4.4.2.5-2** is provided to inform the payload developer of the maximum current carrying capability of each wire gauge. Exceeding the current limits specified in **Table 4.4.2.5-2** will cause pyrolyzation of the payload wiring.	**A**	**A**	**Wiring Derating Analysis**

Paragraph	IRD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.2.6	**Circuit Protection Devices**	Overcurrent protection **shall** be provided at all points in the system where power is distributed to lower level and **shall** be derated according to **Table 4.4.2.6-1** and **Table 4.4.2.6-2**. Fuses and circuit breakers are thermal devices and the lack of natural convection and normal heat dissipation in the microgravity environment causes additional thermal stress on these devices. Fuses and circuit breakers must be derated, or oversized, to ensure they do not trip at a lower current limit than anticipated. Wiring and circuit traces must be sized appropriately for the circuit protection device. For example, a circuit nominally requires a 4A fuse and 24AWG wire, but fuse derating requires the fuse size to be increased to 8A, then the wire will have to be increased to 20AWG to account for the higher capacity circuit protection.	**A**	**A**	**Circuit Protection Report**
4.4.2.7	**EMI**	Payloads connecting to any power source or that are battery powered **shall** comply with the radiated emissions (RE) (RE02) limits defined in SSP 30237, paragraph 3.2.3.1.2.1, at 100 MHz and higher frequencies. Payloads must meet this requirement when integrated within the Black Box. Payload safety-critical circuits that are connected to any power source or that are battery powered **shall** meet the radiated susceptibility (RS) 03 limits defined in SSP 30237, paragraph 3.2.4.2.2, at 100 MHz and higher frequencies. Non-safety-critical circuits *should* meet the radiated susceptibility (RS) 03 limits defined in SSP 30237, paragraph 3.2.4.2.2, at 100 MHz and higher frequencies.	**A**	**T**	**EMI/EMC Test**
4.5	**Command and Data Interface Requirements**			**NVR**	
4.6	**Payload Environments**			**NVR**	
4.6.1	**Thermal Environment**			**NVR**	
4.6.2	**Humidity**			**NVR**	
4.7	**Human Factors**	Payloads **shall** pass an ISS Program Human Factors Interface Team (HFIT) Inspection. The HFIT inspection may take place at the Voyager Exploration facility with NASA oversight during ground processing activities.	**A**	**I**	**HFIT Report**